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ACCURACY, TIMELINESS, AND USABILITY OF EXPERIMENTAL SOURCE DATA MODULES

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Three computer interface systems were developed and tested in a Navy Pay/Personnel Administrative Support System (PASS) office. These three systems were used to analyze personnel performance times, errors, and the effects of computer system parameters on error rates. This report describes the interface systems, discusses their advantages and limitations, and provides recommendations for the future development of a source data entry module for use in personnel office information systems.

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FOREWORD

This research and development was performed in support of program element number 63707 (Manpower Control System Development), project number Z1170-PN (Human Processing of Large Information Automated Data Bases), under subproject Z1170-PN.03 (Improving the Accuracy and Usability of Automated Personnel Information Systems). Sponsorship was provided by the Deputy Chief of Naval Operations (Manpower, Personnel, and Training). Related work was performed under program element number 62763 (Personnel and Training Technology), work unit number ZF55-521-001-022-03.03 (Forecasting New Task Requirements).

The objectives of this effort were to develop and test working models of an interface device that would permit Navy personnel at Pay/Personnel Administrative Support System (PASS) offices to compile accurate and timely inputs to the host personnel information systems. This report describes these interface systems and discusses their test performance in laboratory and PASS office applications.

Appreciation is expressed to Mr. Robert Hawck, who wrote the software. Appreciation is also expressed to the Commanding Officers of the Navy Finance Center, Cleveland, and the Personnel Support Activity, San Diego, and to the Officer in Charge, Personnel Support Detachment, Point Loma, for their support and cooperation.

Finally, the important contributions of the late Senior Chief Personnelman James H. Thompson, USN are acknowledged. Without his expert leadership and full cooperation, data collection in a working Personnel Support Detachment such as Point Loma would have been much more difficult.

JAMES F. KELLY, JR.
Commanding Officer

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Technical Director

SUMMARY

Problem

The Manpower, Personnel, and Training Information System (MAPTIS) and the Joint Uniform Military Pay System (JUMPS) often suffer from inaccurate and out-of-date data. They require costly labor-intensive procedures for correction of errors. There is a need to maintain an accurate, timely, and low-cost data base for both of these large information systems and to improve operation in the many offices that provide the source data.

Objective

The first objective of this R&D effort was to develop and test working models of an interface that would permit personnel at Navy Pay/Personnel Administrative Support (PASS) offices to compile accurate and timely inputs for both MAPTIS and JUMPS while allowing researchers to gather data needed to resolve fundamental human engineering design issues pertaining to man/computer work stations. This interface is herein called the source data entry module (SODEM). The second objective was to develop preliminary specifications for an advanced SODEM incorporating the findings of the research.

Method

Two systems were developed and tested: a simple stand-alone microcomputer system and a more complicated distributed-computer system. The stand-alone system did not include a local data base, but allowed for computer checking of operator inputs and for the machine printing of an optical character reader (OCR) form (the same form that would otherwise be produced in the office with a typewriter). The other configuration was a micro/minicomputer distributed system with a personnel data base.

A system parameter timing study (Williges & Williges, 1982) was conducted to examine minimum and optimum response speeds, work sampling, and embedded performance measurement. It also examined operator satisfaction as a function of various timing parameters of computer systems.

Results

Because of the slow system response of the stand-alone system, it was used very little by office personnel. Although its use would have reduced the incidence of errors, supervisors believed that the error reduction would not compensate for the additional time required.

The distributed system met with favorable user acceptance, largely due to the labor savings it made possible. The distributed system used a faster computer for the main programs, and it had a personnel data base to retain information previously entered. A low error rate was measured for data entered into the system.

As a result of the system parameter timing study, performance prediction equations were generated for a number of system timing parameters. A major finding was that user acceptance seriously deteriorated for system delays greater than 5 seconds or for echo rates greater than 0.75 seconds.

Based on the experience gained in this research, preliminary specifications for a practical SODEM were developed.

Conclusions

The distributed system is satisfactory for improvement of accuracy, timeliness, and usability, and is a useful vehicle for continued study of personnel office information problems.

Accuracy and timeliness can be greatly improved over the previous typewriter/OCR-form method. However, it should be noted that some information cannot be checked automatically. Therefore, the development of improved manual edit and quality control techniques is also necessary.

The time savings and qualitative benefits to the field reporting offices must be considered in addition to accuracy and timeliness of data inputs to the host computer system. Field office benefits are understandably major factors in achieving acceptance by field office personnel.

The technique of installing and using a test device in an operating Navy personnel office proved effective for this study, but added high overhead to the research project in both time and money. In addition, test devices had to be refined to a highly finished and reliable state to induce operational personnel to use them. For these reasons, this method is not recommended for testing marginal or high risk designs.

Recommendations

1. Using the preliminary specifications provided in this report, develop an advanced SODEM for use at operational Source Data System (SDS) sites. This would provide a way to assess the validity and cost-effectiveness of the proposed design and would also provide a basis for enhancing the designs of current and future SDS research programs.

2. Perform additional study of the query-response dialog to improve time performance. A query-response dialog was needed to allow the user control over system functions such as log on, review, change, print, and the like. The dialog selected proved to be slow and error prone (i.e., it provided higher overhead time than the authors desired).

3. Perform additional research and study of field office operation so that SODEM modules for other office applications may be developed that will enhance the cost effectiveness of the total source data system.

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INTRODUCTION

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The Manpower, Personnel, and Training Information System (MAPTIS) and the Joint Uniform Military Pay System (JUMPS) often suffer from inaccurate and out-of-date data, and they require costly labor-intensive procedures for correction of errors. There is a need to maintain an accurate, timely, and low-cost data base for both of these large information systems and to improve operation in the many offices that provide the source data.

Background

MAPTIS and JUMPS are computer-based systems that support management decision making in the Office of the Chief of Naval Operations, the Comptroller of the Navy, the Chief of Naval Personnel, the Commander of the Naval Military Personnel Center (NMPC), and the Commanding Officer of the Navy Finance Center (NAVFINCEN), Cleveland. NMPC and NAVFINCEN are the central design authorities for MAPTIS and JUMPS respectively. MAPTIS and JUMPS entered into the systems by personnel at Personnel Support Detachments (PSDs) using hand-typed optical character recognition (OCR) forms. These forms are then sent via the U.S. postal system to one of two scanner sites where errors are discovered at a rate of 10 to 30 percent when they are machine-read. More than 150 man-years are expended annually in attempting to correct these errors at field offices and OCR scanner sites. In addition to the errors entering the data base, the data is often outdated due to delays of up to 90 days that occur during transit and error correction procedures.

Problems of accuracy and timeliness in large personnel information systems have been a matter of concern for some time due to the costs associated with incorrect and out-of-date personnel information. Many of these problems can be traced to the organization and function of the data entry subsystem and even to the operator-computer interface itself. Obermayer (1977) discussed these problems and their sources and presented a conceptual framework for a source data entry module (SODEM), a kind of operator front end for the data-base system providing error detection and correction functions as well as other operator aids. Such a module could intercept data entry errors before they entered the data base, reducing the editing burden on the main system and the need for time-consuming corrections.

Three interim reports documented Obermayer's ideas. Bailey (1979) surveyed the literature and identified issues that must be addressed in SODEM design. Human Factors Research (1979) identified criteria for performance evaluation. Wylie (1980) provided a SODEM design synopsis based on function allocation, level of automation, and error detection and correction methods.

There is, then, a real need to improve operation in the 3000 offices that provide the source data. The Government Accounting Office (GAO) considers the problem so serious that it submitted a report to Congress entitled: The Navy's Computerized Pay System is Unreliable and Inefficient--What Went Wrong? (GAO, 1980).[1]

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[1]General Accounting Office, GAO FGMSD-80-79, Washington, DC, 1980.

NMPC is currently developing a source data system (SDS) for MAPTIS and JUMPS that will provide:[2]

1. Adequate, accurate, and timely personnel and pay information for developing and implementing the manpower plans and policies of the Navy.

2. Automated PSD input procedures validating and editing criteria, and integrated pay and personnel functions.

3. Accountability of PSD originated events by providing an automated audit trail.

4. An extensive information support capability for PSDs.

5. A two-way telecommunications link between PSDs and the host computers for MAPTIS and JUMPS.

Of course, operator interface problems are not unique to personnel information systems, but are shared among all types of interactive computer systems. While the above references cite the general human-computer interaction literature, two sources are worth noting here. Martin (1973) provided a rather extensive set of information and guidelines for the design of interactive systems and his book serves as a fundamental reference in interactive system research and development. Schneiderman (1980) reviewed the literature prior to and since Martin's work, added to it, and extended the concept of human factors in computer systems to the area of software development.

Nor is the notion of an operator front end module entirely new. Hayes, Ball, and Reddy (1981) developed such a system for an electronic mail system. Future versions of their module will contain adaptive features that respond to the specific characteristics of individual operators.

One objective of the work covered by this report was to develop and test working models of interface devices. The most critical design issues included (1) large information system communication parameters (e.g., system response time, noise, and errors), (2) rapid data entry coupled with computer error-checking methods, and (3) integration of automation into all levels of consolidated personnel offices. Although advanced automation technology is already available, it remains to be determined which applications are most promising, which design trade-offs are best, and whether the return on investment is sufficient to warrant specific technological applications.

Objective

The first objective of this R&D effort was to develop and test working models of a SODEM interface that would permit personnel at Navy Pay/Personnel Administrative Support (PASS) offices to compile accurate and timely inputs for both MAPTIS and JUMPS while allowing researchers to gather data needed to resolve fundamental human engineering design issues pertaining to man/computer work stations. The second objective was to develop preliminary specifications for an advanced SODEM incorporating the findings of the research.

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[2]Automated D. - ~roc' ..ng Selection Office (ADPSO) RFP No. N66032-82-R-0011.

METHOD

Two configurations of a man-computer interface were developed, installed, and tested in an operational Navy personnel office as well as in the Navy Personnel Research and Development Center (NAVPERSRANDCEN) laboratory. Both devices were designed to permit Navy personnel at PASS offices to compile accurate and timely inputs to the MAPTIS and JUMPS systems while also allowing researchers to gather data needed for this project. Robinson, Malone, and Obermayer (1982) reported on some preliminary analyses done for this study.

One configuration was a self-contained office data entry system (SCODES) using a microcomputer and having no personnel data base. This configuration allowed computer checking of operator inputs and the machine printing of the same OCR form that would otherwise have been produced manually on an electric typewriter having an OCR font. It was a minimal configuration consisting of a cathode ray tube (CRT) display and a small microcomputer for editing and error checking.

The other configuration was a distributed office data entry system (DODES) using a micro/minicomputer system that included a personnel data base. Studies were performed with these two configurations to produce data on errors, timeliness, and user acceptance.

An additional study (Williges & Williges, 1982) was conducted to investigate computer system timing parameters. (The Williges & Williges study is summarized in Appendix B.) Timing parameters are important to SODEM design as well as to the assessment of the adequacy of host computer response time; consequently, these data reflect on performance requirements for the entire system and establish parameters required for successful SODEM application.

SELF-CONTAINED OFFICE DATA ENTRY SYSTEM (SCODES)

SCODES was developed to test the effectiveness of using a self-contained system to detect errors as data were being entered into the MAPTIS and JUMPS systems and to collect and analyze detailed information on the quantities and types of errors detected.

Description of SCODES

SCODES represented a minimum system configuration for test purposes and it lacked a supportive data base. Error checking was limited to tests of syntax and format of information being entered--no comparison with previously entered information was possible.

SCODES hardware consisted of a microcomputer with a CRT display, a detachable typewriter-like keyboard, a disk storage device, and a printer capable of printing OCR forms. The system had provisions for automatic error detection, for manual error correction, and for processing the OCR form used for military pay actions (Figure 1). This form was selected because it had a higher documented error rate than any other OCR form. The system also automatically recorded information on detected errors for later analysis.

The software, written in BASIC, prompted the user by means of a question/menu format. The numbered blocks appearing on the form were presented on the CRT screen along with prompts, cues, and detailed explanations. The REASON FOR CHANGE block was known to be the major source of errors and an extensive menu was incorporated into the software to help in the selection of entry codes. When data entry/correction tasks

NFC USE ONLY

NAVCOMPT FORM-OCR 3060

NFC USE ONLY

MILITARY PAY ORDER (SINGLE)

1. UNIT I.D. CODE: 60530	2. DATE (YR MO DA): 76MAR25
3. ORGANIZATION AND STATION: NAVAL WEAPONS CENTER CHINA LAKE CA 93555	IT IS HEREBY AUTHORIZED THAT THE PAY ACCOUNTS OF THE INDIVIDUALS LISTED BELOW BE ADJUSTED AS INDICATED HEREIN:

1

4. NAME (LAST, FIRST, MIDDLE INITIAL)	5. FROM-HR.	6. DATE (YR MO DA)	7. TO-HOUR	8. DATE (YR MO DA)
HALE, RADFORD S	0900	76MAR24		

SSAN		10. AMOUNT	11. REASON FOR CHANGE
[redacted]	E.	$	MESS AVAL

12 REMARKS

2

13 NAME (LAST, FIRST, MIDDLE INITIAL)	14 FROM-HR.	15 DATE (YR MO DA)	16 TO-HOUR	17 DATE (YR MO DA)
18 SSAN		19 AMOUNT $	20 REASON FOR CHANGE	

21 REMARKS

3

22 NAME (LAST, FIRST, MIDDLE INITIAL)	23 FROM-HR.	24 DATE (YR MO DA)	25 TO-HOUR	26 DATE (YR MO DA)
27 SSAN		28 AMOUNT $	29 REASON FOR CHANGE	

30 REMARKS

4

31 NAME (LAST, FIRST, MIDDLE INITIAL)	32 FROM-HR.	33 DATE (YR MO DA)	34 TO-HOUR	35 DATE (YR MO DA)
36 SSAN		37 AMOUNT $	38 REASON FOR CHANGE	

39 REMARKS

5

40 NAME (LAST, FIRST, MIDDLE INITIAL)	41 FROM-HR.	42 DATE (YR MO DA)	43 TO-HOUR	44 DATE (YR MO DA)
45 SSAN		46 AMOUNT $	47 REASON FOR CHANGE	

48 REMARKS

6

49 NAME (LAST, FIRST, MIDDLE INITIAL)	50 FROM-HR.	51 DATE (YR MO DA)	52 TO-HOUR	53 DATE (YR MO DA)
54 SSAN		55 AMOUNT $	56 REASON FOR CHANGE	

57 REMARKS

7

58 NAME (LAST, FIRST, MIDDLE INITIAL)	59 FROM-HR.	60 DATE (YR MO DA)	61 TO-HOUR	62 DATE (YR MO DA)
63 SSAN		64 AMOUNT $	65 REASON FOR CHANGE	

66 REMARKS

67 TOTAL MEMBERS LISTED ON THIS PAGE: 1	69 SIGNATURE OF CERTIFYING OFFICER: V. Varone
68 TYPED NAME AND GRADE OF CERTIFYING OFFICER: VINCENT VARONE, CDR USN	

BY DIRECTION OF THE CO

VALIDATION ERROR

Figure 1. NAVCOMPT 3060, military pay order.

were completed, the information was automatically transcribed onto the OCR form. An option for repeated printing of the OCR form was available to handle those cases where the form did not print properly the first time.

Error-checking software ensured that all necessary (and no unnecessary) entries were made. Other checks were made for appropriate alpha, numeric, special characters, and proper format of data. In each case, errors were presented to the data entry operator for immediate correction at the time (and point) of entry. Based on previous error counts with the existing manual data entry system, the error checks were expected to detect more than two-thirds of the total errors; especially those errors that were most significant. Data on errors were automatically recorded for subsequent statistical analysis.

Field Office Test

Approach

Personnel from the Personnel Support Detachment (PSD), Point Loma were given indoctrination and training to prepare them for operation of the system. This training consisted of demonstrations followed by hands-on sessions for each subject. The system was used in place of the standard electric typewriter for preparing 3060 forms as part of the normal office routine.

Results

The principal test result was that the SCODES was used very little by office personnel. PSD personnel stated that their main reason for not using the SCODES system was that they perceived it to be slower than using a standard electric typewriter. Subsequent experimentation verified that, in fact, additional processing time was required by SCODES. While the use of SCODES would have reduced the incidence of errors, the supervisors believed that error reduction was not adequate compensation for the additional time required in preparing the form. Office personnel did not perceive that they had accrued any benefit from using the system. Therefore, the PSD Point Loma test was terminated early, and the system was moved to the NAVPERSRANDCEN laboratory for further tests in preparation for development of a system that would overcome the shortcomings of SCODES.

Laboratory Test

Approach

In addition to ensuring that SCODES would be used, moving the experiment back into the NAVPERSRANDCEN laboratory environment allowed for controls that could not be imposed in the field (e.g., control of lighting and interruptions). Conducting the experiment in the laboratory also allowed the experimenter to monitor the experiment personally as it was being performed.

Three Navy personnelmen (PNs) stationed at NAVPERSRANDCEN and a NAVPERSRANDCEN professional were used as subjects for the laboratory experiment. SCODES and a standard electric typewriter were used by the test subjects to prepare NAVCOMPT 3060 OCR forms in the laboratory experiment. All subjects were experienced in the preparation of OCR forms using a standard electric typewriter and were trained in the use of SCODES. The subjects were tested on both methods shortly after the orientation period and again after 6 weeks' experience with the system. Each subject's experience

was labeled "inexperienced" (less than 1 week) and "experienced" (6-9 weeks). The data from these tests are summarized in Table 1.

Table 1

Preparation Time (minutes) for NAVCOMPT Form 3060

Tasks	SCODES Inexp	SCODES Exp	OCR Typewriter Inexp	OCR Typewriter Exp
Single entry				
Data entry	2.6	2.1	1.5	1.8
Edit	.5	.4	--[a]	--[a]
Print	3.0	.8	--[b]	--[b]
Total	6.1	3.3	1.5	1.8
Multiple entries				
Data entry	7.8	5.9	3.9	4.3
Edit	1.5	.6	--[a]	--[a]
Print	2.2	1.5	--[b]	--[b]
Total	11.5	8.0	3.9	4.3

[a]Editing performed after the form is typed.

[b]Data entry and printing performed concurrently.

Results

The individual and total time comparisons indicated that using SCODES required more time than using the standard electric typewriter. The situation was particularly unfavorable to SCODES when a single transaction for one member of the service was recorded. In this case, the data could be entered in approximately half the time when using the standard typewriter. Even forms with multiple entries were produced faster (80% of the computer time) when using the typewriter. In addition to the entry time, the operator using the SCODES was required to display the completed form on the CRT for review, edit, and then print the final form. However, when errors were discovered on forms prepared using the typewriter, the form had to be completely retyped, incurring additional time. Measurement of the manual task did not include review and edit time by the data entry operator or supervisory personnel. No data are available for review time in the office. Interviews with experienced personnel indicated that review time can vary widely with different offices and/or reviewers. However, the error checking features were not considered to be an offsetting positive factor by the test subjects and supervisory personnel.

Conclusions from Testing of SCODES

Based upon results of the office and laboratory tests of SCODES, it was determined that:

1. The use of a BASIC interpreter as a programming language is unacceptable because it it too slow.

2. A system with more capability than the microcomputer used for SCODES is required.

3. Errors can be significantly reduced by utilizing stored information to avoid retyping unchanged information each time a form is updated.

4. An automated device for data entry must benefit the office entering the data as well as provide an acceptable end product to the receivers of the data (NMPC and NAVFINCEN).

DISTRIBUTED OFFICE DATA ENTRY SYSTEM (DODES)

It was clear from the experience with SCODES that a successful office data entry system would have to reduce the office's work load or increase its productivity. It should also reduce errors and have the potential for electronic submission of data. Electronic data submission would greatly reduce the problems and time associated with printing and maintaining paper forms. It would also provide other benefits, such as the compilation and printing of routine management reports. It is to these ends that an improved system, the distributed office data entry system (DODES), was developed to collect performance measurements and design data unobtrusively.

Description of DODES

While SCODES was designed to prepare the NAVCOMPT 3060 form, which is a short form but one which has a high accompanying error rate, DODES was designed to prepare a long form that requires tedious preparation: the Dependency Application/Record of Emergency Data form, NAVPERS 1070/P602R, also commonly referred to as the "page 2" (Figures 2 and 3).

To reduce computer response time, a distributed computer system was implemented. A microcomputer was used in the office to control input/output (I/O) from the operator in response to commands from a remote minicomputer. The display formats of prompts (e.g., requests for data) were stored on a "floppy disk" and were presented on the operator's CRT upon command from a remote minicomputer. The microcomputer also performed the operations necessary to collect data on operator response and typing times. The microcomputer then transmitted these data back to the minicomputer. Data storage and the bulk of the computation, edit checks, and control functions were performed by the minicomputer. All of the logic necessary to carry out the processing of a Record of Emergency Data form was under control of the minicomputer. The minicomputer controlled all of the processing requests to the microcomputer system for data input, the editing of data for correct format and content, the formatting of data for storage and retrieval, the formatting of data for printing of OCR forms and/or display on the CRT, and the retrieval of existing records for review and/or update.

DEPENDENCY APPLICATION/RECORD OF EMERGENCY DATA

1. UNIT I.D. ¬4675 | 2. SHIP OR STATION USS TOWERS DDG 9 | 3. | 4.

5. NAME OF SPOUSE ANN LYNN CURRY LOGAN | [redacted] | 7. RELATIONSHIP WIFE

8. PLACE OF MARRIAGE (CITY & STATE OR COUNTRY) CHARLESTON, WV | 9. DATE MARRIED 75JUN18 | 10. CITIZENSHIP OF SPOUSE US

[redacted] | 12. DEP YES

13. NAME OF CHILD OR DEPENDENT PETER SAMUEL LOGAN | [redacted] | 15. RELATIONSHIP SON

16. ADDRESS (INCLUDE NAME OF CUSTODIAN IF OTHER THAN CLAIMANT) NANCY P. LOGAN LEG GDN, 599 REESE RD, ERIE, PA 16510 | 17. DEP YES

18. NAME OF CHILD OR DEPENDENT | 19. DATE OF BIRTH | 20. RELATIONSHIP

21. ADDRESS (INCLUDE NAME OF CUSTODIAN IF OTHER THAN CLAIMANT) | 22. DEP

23. NAME OF CHILD OR DEPENDENT | 24. DATE OF BIRTH | 25. RELATIONSHIP

26. ADDRESS (INCLUDE NAME OF CUSTODIAN IF OTHER THAN CLAIMANT) | 27. DEP

28. NAME OF CHILD OR DEPENDENT | 29. DATE OF BIRTH | 30. RELATIONSHIP

31. ADDRESS (INCLUDE NAME OF CUSTODIAN IF OTHER THAN CLAIMANT) | 32. DEP

33. NAME OF FATHER JACK EDWARD LOGAN, DECEASED

34. ADDRESS OF FATHER (SEE SPECIAL INSTRUCTIONS BEFORE COMPLETING BLOCK 35) | 35. DEP

36. NAME OF MOTHER SYLVIA PAULA SMITH LOGAN

[redacted] | 38. DEP YES

39. WERE YOU PREVIOUSLY MARRIED? [X] YES [ ] NO | 40. PRIOR MARRIAGE DISSOLVED BY [ ] DEATH [ ] ANNUL-MENT [X] DI-VORCE | [redacted] | 42. PLACE (CITY & STATE OR COUNTRY) PHILA PA

43. WAS SPOUSE PREVIOUSLY MARRIED? [ ] YES [X] NO | 44. PRIOR MARRIAGE DISSOLVED BY [ ] DEATH [ ] ANNUL-MENT [ ] DI-VORCE | 45. DATE | 46. PLACE (CITY & STATE OR COUNTRY)

47. OTHER | 48. ADDRESS | 49. RELATIONSHIP

50. NEXT OF KIN OF SPOUSE (NOT HUSBAND, WIFE OR MINOR CHILD) ALICE BIRD SOMMERS | [redacted] | 52. RELATIONSHIP SISTER

53. BENEFICIARY(S) FOR UNPAID PAY AND ALLOWANCES ANN LYNN LOGAN | [redacted] | 55. RELATIONSHIP WIFE | 56. % 80

57. PERSON TO RECEIVE ALLOTMENT IF IN A MISSING STATUS, SUBJECT TO SECNAV DETERMINATION ANN LYNN LOGAN | [redacted] | 59. % 100

60. BENEFICIARY(S) FOR GRATUITY PAY (NO SPOUSE OR CHILD SURVIVING) SYLVIA PAULA LOGAN | [redacted] | 62. RELATIONSHIP MOTHER | 63. % 100

64. LIFE INSURANCE DATA (NAME OF CO.) (DO NOT INCLUDE SGLI) PRUDENTIAL LIFE INSURANCE CO. | [redacted] | 66. POLICY NUMBER 433210

67. RELIGION 58 | 68. | 69. | 70. RANK/RATE SKSN | 71. PAGE 1 | 72. OF PAGES 1

73. NAME OF DESIGNATOR (LAST, FIRST, MIDDLE) LOGAN, LEONARD ALBERT | [redacted] | 75. USN [ ] | 76. USNR [X]

DEPENDENCY APPLICATION/RECORD OF EMERGENCY DATA NAVPERS 1070/602 (REV. 7-72) PART II

Figure 2. Front page of NAVPERS 1070/P602R.

NAVPERS 1070/602 (REV. 7-72) (PART II) (BACK)

77. LOCATION OF WILL OR OTHER VALUABLE PAPERS

NONE

78. REMARKS

16 CHILD SUPPORT $50 PER MONTH COURT ORDER 56 20%
TO EX-WIFE AS LEGAL GUARDIAN. 61 WV 25314
36 CONTRIBUTION $100 PER MONTH.
51 25314
53 SYLVIA PAULA LOGAN
54 623 HILLVIEW DR, CHARLESTON, WV 25314
55 MOTHER

Is beneficiary designation of S.G.L.I. on file? [X] YES [ ] NO DATE (if yes) 76JAN25

NOTE: THIS FORM DOES NOT DESIGNATE OR CHANGE BENEFICIARIES OF GOV'T LIFE INSURANCE.

79. SIGNATURE OF DESIGNATOR	80. SIGNATURE OF APPROVING OFFICER, TITLE, AND DATE
Leonard Albert Logan	A R Small A. R. SMALL, PERS OFF, 76JAN30

CERTIFICATION OF DESIGNATOR

I have reviewed the data entered on this form and certify that it is correct.
Execute a new NAVPERS 1070/602 if the data is not correct.

DATE	SIGNATURE OF DESIGNATOR	DATE	SIGNATURE OF DESIGNATOR

Figure 3. Back page NAVPERS 1070/P602R.

Programming was done in assembly language on the microcomputer, and in a high-speed, high-level language on the minicomputer. The microcomputer was a Futuredata 8/16 based on an Intel 8080 microprocessor; the minicomputer was a Digital Equipment Corporation PDP 11/45 running under the UNIX operating system and using C as its primary programming language. The minicomputer also incorporated a large disk memory, permitting the storage of completed 602 forms for all personnel serviced by a PSD. It also permitted the modification of forms without completely reentering all information as is required using the current typewriter OCR method. Additionally, the DODES data base was available for printing summary reports, providing audit trails, and for other office needs.

Laboratory Test

Prior to installing DODES in the field, tests were performed in the NAVPERSRANDCEN laboratory under controlled conditions. A direct comparison with the current manual method was made.

Method

Equivalent sets of simulated "page 2" personnel data were created for use in both the manual and DODES tasks. The data to be entered were carefully matched for the experiment so that the number of characters and finger/keyboard usage were balanced across experimental treatments. Seven men and three women were selected from a pool of Navy personnelmen (PN rating) and Navy civilian clerical personnel. All were experienced typists familiar with Navy procedures and the preparation of Navy OCR forms. The subjects were given brief written instructions that explained the experiment, and a users' manual was reviewed with each operator. Each operator was then given the opportunity to practice completing "page 2s" on the DODES before participating in the controlled experiment.

DODES task. Each subject filled out two separate page 2s using the computer (80 blocks on each form). After the forms were completed, subjects were asked to make two changes on a page 2 form that was already on file in the computer data base. The following measurements were recorded automatically by the computer for each task completed by each subject:

1. The elapsed time between the time a query was presented on the CRT and the time the subject responded with a keystroke.

2. The elapsed time between the first keystroke response to a query and the next carriage return (carriage returns signaled the completion of tasks).

3. The number of times that the backspace key was struck (a measure of the number of errors detected and corrected by the subject (commonly referred to as "typos"/"strikeovers")).

4. Errors detected by the computer and called to the operator's attention for immediate correction.

Manual task. The manual task consisted of typing two forms on an IBM Selectric typewriter with an OCR font. The subjects were required to fill in blocks 1-46 and 67-76 on the front page with carbons inserted for copies 2 through 5, remove the form from the typewriter, reinsert copies 4 and 5, and fill in blocks 47-66. The backs of Part I and Part II had to be filled out separately (turning the forms over, reversing their order and

reinserting the carbon paper) since the back of the form contained additional information. A stopwatch accurate to a tenth of a second was used to time the subjects on each form. Errors were broken down into two categories: (1) detected and corrected, and (2) undetected (i.e., errors that would have gone into the data base).

Results

A summary of the timing data is presented in Table 2. The amount of time required to enter a complete form was not significantly different for either method; however, a change could be produced using the computer in about 1/4th the time since the manual method required completely retyping the form. Clearly, the keystrokes "saved" by using the computer supported system can be a significant benefit to the office for this task.

Table 2

Time Required to Complete or Change Dependency Application/Record of Emergency Data Forms NAVPERS Form 1070/P602R

	Tasks (minutes per form)		
	DODES		
Measures	Entering New Form	Changing a Form[a]	Manual Entry
Entry and Printing:			
Mean	14.56	4.13	16.46
Median	14.20	4.11	14.60
Mode	11.18, 17.50[b]	4.11	10.38
Variance	8.75	2.34	42.26
Standard Deviation	2.96	.58	6.50
Entry Time Mean	12.20	2.20	--[c]
Printing Time Mean	2.40	1.89	--[c]

[a]Two changes made to a completed form in the data base file.

[b]Bimodal

[c]Not applicable--Entry and printing occurred concurrently.

Table 3 indicates that the number of undetected errors that would have entered the Navy's master data base was significantly greater for forms filled out manually than for forms completed using DODES. Operators detected and corrected significantly more errors when entering the forms on the computer system. The error rate for forms in the DODES data base was 0.55 errors per form; virtually no undetected errors would have entered the MAPTIS/JUMPS data base.

Table 3

Error Rates for DODES and Manually Prepared Dependency Application/Record of Emergency Data Forms NAVPERS Form 1070/P602R

	Tasks					
	Computer Entry		Data Change[a] using Computer		Manual Entry	
Type of Error	Mean	%	Mean	%	Mean	%
Operator Detected/Corrected	8.25	87	.10	33	3.00	70
Computer Detected/Operator Corrected	.70	7	.20	67	--	--
Total Detected Errors	8.95	94	.30	100	3.00	70
Undetected Errors[b]	.55	6	.00	0	1.30	30
Total Errors	9.50	100	.30	100	4.30	100

[a]Two changes made to a completed form in the data base file.

[b]Errors that would have been transmitted to the data base.

While the number of errors entering the data base when DODES was used was minimal, examination of Table 3 reveals a paradox. The operators using DODES made more errors than did the operators using the current manual system. Using DODES evidently allowed the operators a less stressful working environment. They knew that, when they made a mistake, they could backspace and overtype an error with the correction, a luxury not always afforded in the manual system. Also, they knew that errors detected by DODES would be presented for immediate correction and those detected by them at a later time could be corrected without having to completely reenter all of the data contained on the form.

Field Office Test

Method

DODES was used for data entry of complete Records of Emergency Data (NAVPERS FORM 1070/P602R) by personnelmen at the Point Loma PSD and by university students and civil-service personnel employed by NAVPERSRANDCEN. As a result of these efforts, a substantial data base was created for more than half of the total number of personnel served by the Point Loma PSD (the data discussed in this report are based on 1123 forms; however, data were entered for 1891 personnel). This data base could be used for reporting changes as they occurred (with substantial time savings compared to the current method of completely retyping a form each time a change is required). However, most of the activities reported here were associated with creation of complete records (and the correction of errors made while creating these records). In addition to providing research data, this data base was used as a means for updating individual records and for conducting periodic reviews for the accuracy of existing records.

Distribution of Time

A little less than one-half of the time was used for activities other than direct data entry; however, only about one-tenth of the total time was used for administrative system functions such as selecting and controlling the sequencing of data entry. The percentages of time used for various tasks in preparing the Emergency Data form are listed below:

1. Add new records, 53 percent.
2. Print records, 23.2 percent.
3. Record retrieval, 11.8 percent.
4. Administrative time, 7.7 percent.
5. Change/modify records, 4.3 percent.
6. Display/view records, less than 1 percent.

Analysis of Data Entry Time

As the operator entered data at the computer terminal, measurements were automatically recorded on operator response time to a query (time from display of a query on the CRT until the operator depressed the first key), the time the operator spent waiting on the system, and the number of times the back space key was used (an indication of a possible operator-detected error). Data were also collected on the number and types of errors detected by the system and flagged for correction by the operator. A tabulation of the time measurement for each block of the Emergency Data form is presented in Table 4.

These data are grouped by type of response in Table 5. It is apparent that the largest factor affecting data entry time is the length of the entry; that is, longer typing time, longer total time, and increased use of the back space results when names and addresses must be entered. Otherwise, there are few apparent differences.

Analysis of Errors

An analysis of errors detected by the system showed that approximately 60 percent of all errors took place during data entry (Table 6). The remainder occurred when the operator responded inappropriately to system prompts such as "enter password and user log-in name." Further effort should be directed at reducing these errors.

Additional analyses of data entry errors are presented in Tables 7 and 8. Table 7 presents error rates by block number, while Table 8 presents an error count by block number and specific type of error. It is not clear why dates were wrong more often in some blocks than in others, or why some yes/no responses gave such difficulty.

Timing Parameters

A system timing parameter study was performed by Williges and Williges (1982) as part of this work. This study, which is summarized in Appendix B, indicated that operator performance begins to degrade when the system response time (the time the operator is waiting on the system) is greater than 4 seconds. The system response time for the DODES study was judged acceptable by the users.

Table 4

Performance Measurement Data For Record of Emergency Data
(NAVPERS Form 1070/P602R) (Tabulated by Block)

Block No.	Entry Requested	No. of Times Used	Time (Seconds) Operator Response	Typing	Operator Waiting	Total Time	Entries with Back-spaces (%)
1	Unit I.D. (UIC)	577	2.7	2.7	0.6	6.0	4.0
2	Name of ship or station	116	3.5	6.3	0.6	10.4	33.6
3/4	Initial entry or change (I/C)	579	1.2	0.4	0.5	2.1	0.7
5	Name of spouse	290	3.0	10.9	0.6	14.5	32.4
6	Date of birth (DOB) of spouse	345	2.1	3.9	0.6	6.6	3.8
7	Relationship of spouse (H/W)	350	1.5	0.6	0.5	2.6	2.3
8	Place of marriage	343	1.3	6.1	0.6	8.0	28.3
9	Date married	353	2.5	3.8	0.5	6.8	4.8
10	Citizenship of spouse	347	1.0	1.5	0.9	3.4	5.5
11	Address of spouse	169	2.1	17.2	0.7	20.0	52.1
12	Dependent	348	1.8	0.8	0.5	3.1	3.2
13	Name of child or dependent	277	2.0	7.9	0.8	10.7	36.8
14	DOB	288	1.9	5.0	0.6	7.5	6.6
15	Relationship	284	1.4	0.5	0.9	2.8	2.5
16	Address	49	1.5	33.6	1.3	36.4	67.3
17	Dependent	286	0.7	0.4	0.9	2.0	0.3
18	Name of child or dependent	196	1.5	8.9	0.6	11.0	36.7
19	DOB	194	2.0	4.5	0.4	6.9	4.6
20	Relationship	197	1.0	0.4	1.0	2.4	1.0
21	Address	31	1.5	15.2	1.4	18.1	54.8
22	Dependent	196	0.8	0.4	0.9	2.1	1.5
23	Name of child or dependent	106	2.2	6.6	0.8	9.6	22.6
24	DOB	92	2.1	4.0	0.6	6.7	2.2
25	Relationship	95	1.4	0.4	0.9	2.7	2.1
26	Address	15	1.9	12.5	1.1	15.5	60.0
27	Dependent	93	0.6	0.5	0.9	2.0	2.2
28	Name of child or dependent	37	2.1	7.6	0.8	10.5	32.4
29	DOB	33	1.7	4.2	0.5	6.4	3.0
30	Relationship	36	1.1	0.5	0.9	2.5	2.8
31	Address	3	3.8	19.7	1.5	25.0	66.7
32	Dependent	34	0.6	0.5	0.7	1.8	0.0
33	Name of father	531	1.1	9.5	0.9	11.5	31.1
34	Address	273	11.8	15.8	0.7	28.3	46.9
35	Dependent	455	1.3	0.7	0.6	2.6	2.6
36	Name of mother	463	1.6	12.0	0.7	14.3	32.0
37	Address	283	1.7	17.7	0.6	20.0	48.4
38	Dependent	512	1.5	0.6	0.5	2.6	2.1
39	Were you previously married	573	2.6	0.6	0.4	3.6	1.9
40	Prior marriage dissolved by	75	1.5	0.6	0.5	2.6	4.0
41	Date of dissolution	79	2.0	4.2	0.6	6.8	8.9
42	Place of dissolution	77	1.3	11.5	0.6	13.4	27.3
43	Spouse previously married	497	0.9	0.4	0.5	1.8	0.6
44	Prior marriage dissolved by	48	1.5	0.6	0.6	2.7	4.2
45	Date of dissolution	48	2.2	3.9	0.6	6.7	0.0
46	Place of dissolution	48	1.3	5.4	0.5	7.2	22.9
47	Name of other to be notified	73	2.1	6.3	0.8	9.2	43.2
48	Address of "other"	28	1.5	17.7	0.8	20.0	60.7
49	Relationship of "other"	59	1.6	2.9	0.6	5.1	20.3
50	Next of kin (NOK) of spouse	544	1.2	4.9	0.6	6.7	18.0
51	Address of NOK of spouse	184	1.5	15.5	0.5	17.5	49.5
52	Relationship to spouse	325	0.9	2.1	0.5	3.5	17.2
53	Beneficiaries for pay/allowances	634	1.7	9.1	1.0	11.8	37.2
54	Address	343	1.8	16.5	1.2	19.5	47.5
55	Relationship	637	1.6	2.0	0.6	4.2	13.7
56	Percent	629	0.9	1.1	0.5	2.5	1.0
57	Person to receive allotment	518	1.2	7.4	0.7	9.3	27.8
58	Address	313	1.7	18.5	0.6	20.8	50.2
59	Percent	536	1.5	1.2	0.8	3.5	4.3
60	Beneficiaries for gratuity pay	627	2.6	8.1	0.9	11.6	33.5
61	Address	366	1.5	17.4	1.2	20.1	45.0
62	Relationship	646	1.4	2.7	0.6	4.7	18.7
63	Percent	642	0.8	1.1	0.6	2.5	2.2
64	Name of life insurance company	250	2.1	7.7	0.6	10.4	34.4
65	Address	221	1.7	7.7	1.8	11.2	29.0
66	Policy number	251	2.1	10.2	1.4	13.7	15.5
67	Religion	560	1.9	1.0	2.8	5.7	3.9
69	Effective date of form	566	7.3	4.9	0.6	12.8	3.9
70	Rank/rate	1120	3.1	1.5	1.4	6.0	2.5
73	Name of applicant	535	3.3	9.4	0.8	13.5	37.8
74	Applicant's SSN	1178	9.5	6.4	4.8	20.7	16.3
75/76	USN/USNR	558	1.3	0.4	0.5	2.2	2.3
77	Location of will	509	7.7	4.1	0.8	12.6	8.6
78	Remarks	91	4.3	16.7	0.9	21.9	41.8
80	Certifying officer	1026	2.8	0.6	3.9	7.3	0.5
81	Name SGLI beneficiary on file	567	1.9	0.7	0.5	3.1	1.9
82	Date of SGLI designation	116	1.9	5.5	0.5	7.9	9.5
83	Date of last certification of form	551	2.7	4.5	0.4	7.6	5.6

Table 5

Performance Measurement Data for Record of Emergency Data (NAVPERS Form 1070/P602R) (Grouped by Similar Blocks of Data)

Block Numbers	Type of Entry	No. of Times Used	Time (Seconds) Operator Response	Typing	Operator Waiting	Total	Entries with Back-spaces (%)
3, 12, 17, 22, 27, 32, 35, 38, 39, 43, 81	Single character alpha response	4140	1.5	0.6	0.5	2.6	1.7
40, 44, 75	Single number from table	681	1.3	0.5	0.5	2.3	2.6
5, 13, 18, 23, 28, 33 36, 47, 50, 53, 57, 60 64	Names	4546	1.8	8.5	0.7	11.0	31.0
6, 9, 14, 19, 24, 29, 35, 41, 45, 82, 83	Dates (7 character format)	2554	2.1	3.7	0.5	6.3	4.8
8, 11, 16, 21, 26, 31, 34, 37, 42, 46, 48, 51 54, 58, 61, 65	Addresses (free format)	2746	2.6	14.8	0.9	18.3	43.7
15, 20, 25, 30	1-2 position number from table	612	1.3	0.5	0.8	2.6	2.0
49, 52, 55, 62	Relationship (not from table)	1667	1.4	2.4	0.5	4.3	16.5
56, 59, 63	1-2 digit number (not from table)	1807	1.1	1.1	0.6	2.8	2.4

Table 6

Error Count by Type of Entry

Type of Entry	Error Count[a]	Percent
Data Entry:		
Data entry to block on form	500	59.7
Entry of SSN	14	1.7
System Prompts:		
User log-in name	146	17.4
Select block to change	62	7.4
Branch in program	52	6.2
Select type of form	30	3.6
Verify return code	25	3.0
Line printer select	8	1.0
Total	837	100.0

[a]Based on 1123 forms.

Table 7

Error Rate by Block Number

Block Number[a]	Error Rate[b]	Contents of Block
14	.17	Date of birth (#1 child)
47	.16	Name of other person to be notified
41	.14	Date of dissolution of previous marriage
82	.14	Date of SGLI
17	.05	Spouse dependent (yes/no)
65	.05	Address of insurance company
55	.04	Relationship of beneficiary
9	.04	Date of marriage
36	.04	Name of mother
8	.04	Place of marriage
10	.04	Citizenship of spouse
39	.03	Previously married (yes/no)
50	.03	Name of next of kin of spouse
80	.03	Name of approving officer and title
83	.03	Date of last certification (review of form)
67	.02	Religious preference
43	.02	Was spouse previously married? (yes/no)
53	.02	Name of beneficiary
60	.02	Beneficiary for gratuity pay
70	.01	Rank/rate

[a]For those blocks with more than 10 errors. (Sample consisted of 1123 forms.)

[b]Relative frequency with which an error was made when entering data for block.

Table 8

Error Count by Block Number and Error Type

Block	Error Description	Error Count[a]
14	Incorrect month--not Jan., Feb., etc.	20
80	No selection or entry made for name of certifying officer	20
55	Character other than alpha or space for relationship of beneficiary for unpaid pay and allowances	20
39	Entry other than y or n for "were you previously married?	19
14	Year not numeric, DOB of 1st child	15
17	Entry other than y or n, child dependent?	15
67	Religion code not in table	13
8	Character other than alpha or space, place married	12
14	DOB of 1st child later than effective date of form	11
36	Less than two word name of place where spouse's previous marriage was dissolved.	11
43	Other than y or n, "was spouse previously married?"	11
55	Character other than alpha or space, relationship of beneficiary for unpaid pay and allowances	11
50	Less than given and surname entered for next of kin of spouse	10
9	Date of marriage later than effective date of form	10
35	Other than y or n entered, dependent father	9
59	Nonnumeric entry, percent missing status allotment	9
5	Character other than alpha or space, name of spouse	9
15	Not on list or not numeric	9
70	Rank or rate does not match list	9

[a]For entries with more than 10 errors in 1123 forms.

PRELIMINARY SPECIFICATIONS FOR A PROPOSED SOURCE DATA ENTRY MODULE (SODEM)

This section provides a functional description of the components of a proposed source data entry module (SODEM).

Design Goals

The design goals for the SODEM, derived from the experimental results and the researchers' exposure to personnel office operations, are to:

1. Increase data accuracy through good system design and automated error detection and correction.

2. Improve data timeliness through increased emphasis on local, as opposed to centralized, error detection and correction.

3. Provide adaptive features that automatically adjust to the user's level of skill.

Design Philosophy

In a rapidly changing technological environment, systems must be flexible and expandable. At the same time, they must respond rapidly to user inputs. To obtain all of these characteristics in the proposed SODEM, a design philosophy based on modularity and on the simultaneous processing of input and output data was adopted.

Whenever possible, the SODEM design was developed with a module-per-function structure in order to facilitate system modification as new concepts and technology become available. These modules will be implemented in an event-driven, multiprogramming environment to take advantage of input/output parallelism, thereby improving overall system response parameters.

Finally, it was decided to make the SODEM as transparent to the user as possible. In most cases, the SODEM would be added to an already-existing data base management system as a front end. It should in no way interfere with or alter normal system operation and its presence should only be apparent when its special features are called for.

Functional Description

The following functional description of the SODEM is preliminary and intended to give the details needed to make further definition and prototyping possible.

The SODEM design is based on the assumption that the host system hardware environment, through which it interfaces to the personnel data base, will be similar to the Navy's PASS/SDS system. In such a system, the master data base is maintained at a central site and remote host processors (RHPs) communicate with the central site. Field transactions are made at terminals connected to the RHPs through multiplexing systems.

One design approach would be to implement SODEM software in the RHPs, thus eliminating the need for additional hardware. While this might seem to be an economical idea, it is technically infeasible because host processing activities already require all available CPU, memory, and peripheral resources. Instead, the proposed SODEM would be a hardware/software entity interposed between the RHPs and the operator terminals to

intercept and translate communications between RHPs and operators. In this configuration, the SODEM could provide its additional capabilities to the operator without using host processor resources or time.

Hardware Specifications

Specifically, SODEM will consist of a microcomputer system with at least 64K bytes of random access memory, vectored interrupts, and a real-time clock for timing purposes. On-line storage will be provided by floppy disks, Winchester-type fixed-media disks, or a combination of both. Communications will be via serial line interfaces (RS 232) to both the host system and to the operator's terminal. To the operator, the SODEM will look like an RHP with advanced features; to the RHP, the SODEM will look like an operator terminal. The hardware configuration is diagrammed in Figure 4.

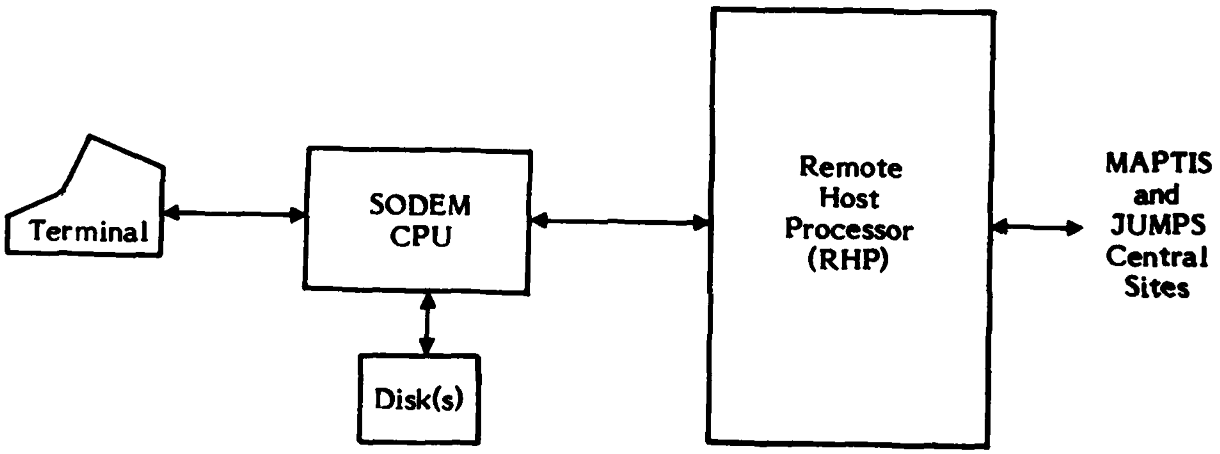

Figure 4. SODEM hardware configuration.

Software Specifications

Again, assumptions about the host software environment are based on PASS/SDS. In such a system, data base management software allows personnel to add, modify, and delete records, perform queries, and generate reports. The operator interface is provided through screen-oriented terminal I/O software that presents CRT screens of information, including menus and forms, to the operator and allows the operator to enter, examine, and modify the currently relevant data.

Such a system allows two forms of SODEM interfaces to be considered. In the first, no modification would be required to their host software. Instead, the SODEM would emulate the operator, accepting screens of display information and returning input data in the form the operator would normally enter it. In the second scheme, modifications would be required to the host's terminal I/O software which would then send and receive internally coded information to and from the SODEM.

The first scheme eliminates the need for host modification at the cost of increased complexity of SODEM software. The second economizes SODEM-host communication while requiring possibly significant changes to host software. The specific requirements of each application will have to be taken into account in the development of prototype and operational SODEMS.

The SODEM will be a modular, real-time, multiprogramming system, controlled by a supervisory module. Figure 5 illustrates the overall organization of the modules. Modules, called procedures here, will communicate via a shared portion of dynamic memory that will also be used for storage of information relating to the current terminal session.

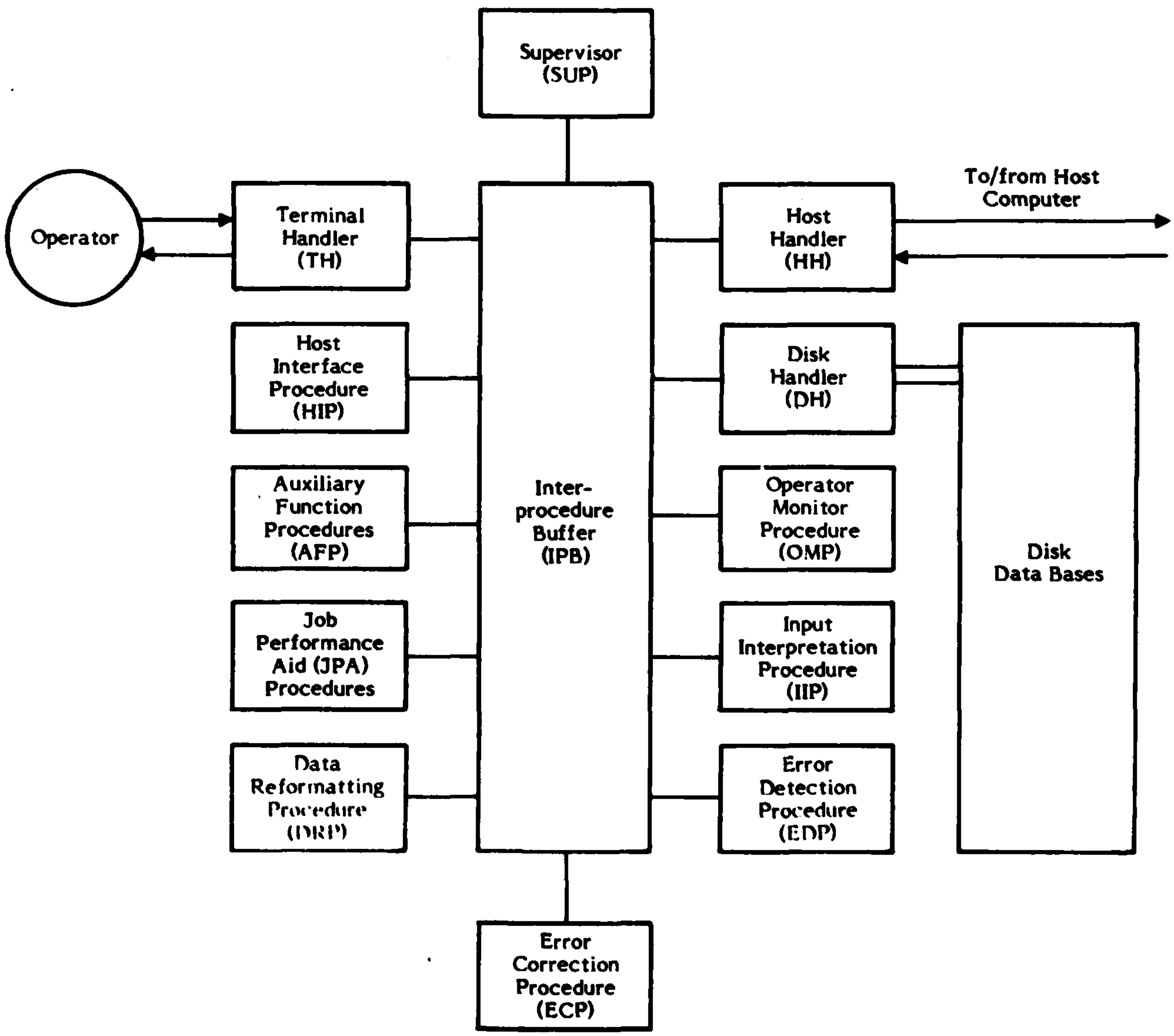

Figure 5. Organization of SODEM software modules.

Hardware interrupts will provide the most basic level of procedure synchronization. These interrupts will be due to I/O operations of the operator's terminal, the host system interface, and the on-line disk subsystems. In addition, timing interrupts will be generated by the real-time clock.

At the functional level, the SODEM will be considered to be event-driven, where functional procedures respond to external or internal events to provide appropriate processing. Events will include the completion of an I/O operation, such as receipt of a termination character following operator input of a data item or the display of the final character in a prompt or error message. Another class of events will consist of procedure completions. It will be the responsibility of each processor to detect and flag certain kinds of events so that the supervisor procedure may invoke other procedures to service these events. In addition, the procedure that flags an event may generate a message about that event to inform the invoked procedures about its nature and characteristics.

At any given time, several procedures may be attempting to process an event simultaneously. One procedure may be attempting to display an error message to the operator, another may be attempting to read input from the host, and still another may be in the process of computing a performance measure. These procedures would then be said to be in competition for SODEM resources. In some cases, such activities could take place in parallel, as when two independent I/O processes are in progress. Many times, however, as with the use of the CPU, sequential processing must be enforced. The supervisor module (SUP) will arbitrate among competing procedures and allocate resources in accordance with a priority scheme.

The arbitration process may be described with regard to how the supervisor will deal with certain classes of procedures. SUP will maintain a procedure table that lists the characteristics of each procedure of SODEM. Most procedures will initially be in an inactive state. Inactive procedures are those that are waiting for an event to occur, as an error detection procedure would need to wait for the completion of operator input. For each inactive procedure entry in the procedure table, there will be reference to the event(s) being waited on.

When an event, such as an I/O or procedure completion, occurs, SUP will search the procedure table to see if any procedures are waiting on that event. If so, those procedures will become active, eligible to compete with others for SODEM resources. They will also be given a priority that will be used in the arbitration process. Similarly, procedures that have been completed will be declared inactive in the procedure table and will no longer compete for resources until their event occurs again.

Of the active procedures, only a subset may be allowed to execute. While the I/O handlers will respond immediately to interrupts and will therefore not be under direct control of SUP, only a single procedure will be allowed to execute. The executing procedure will be the active procedure with the highest priority. Priority will be dynamic and the priority of a given procedure will depend upon its immediate importance in satisfying overall system objectives.

Those active procedures not executing will be termed suspended. For example, a procedure will be suspended if it is waiting for an I/O process to complete, if it is waiting for a specific event to occur, or if it is simply preempted by a higher-priority procedure.

While SUP will oversee I/O operations and control procedure states, the actual sequencing of the SODEM will be performed cooperatively by the procedures themselves. This feature will allow flexibility in applying the SODEM to different data base systems.

The function and major characteristics of all components of the SODEM are described in Appendix A.

CONCLUSIONS

Effectiveness of the Distributed System

A common but nevertheless important finding was that user acceptance is an enabling requirement for the design of human-computer systems. Without user acceptance, excellence of design in other areas can be largely wasted effort. The distributed system received user acceptance while the self-contained system did not. This result is clearly due to two design features:

1. A computer system must aid the user in performing the work assignment, and preferably reduce the work load. Furthermore, as the study of system timing parameters (Williges & Williges, 1982) indicates, system response time must meet stringent user standards.

2. The DODES offered a clear advantage in terms of office efficiency. Changes to previously entered forms could be made without retyping the entire form, while use of the manual method required complete retyping for even the simplest changes. The keystroke reduction made possible by DODES was a major factor in its having achieved acceptance by the users.

Manual Review Requirements

An important feature of the current application of automation is that a significant number of data entry errors can be automatically detected. However, it is clear that not all errors can be detected automatically. The designer of computerized systems for data entry should therefore consider the requirement for manual review. Possibly because of the ease of operator review on the test system, the number of undetected errors was less than experienced with the manual typewriter method. Nevertheless, additional design attention to manual review needs would probably result in further improvement. In particular, methods to incorporate review by individuals other than the one who entered the data should be pursued.

Office Automation

The primary emphasis of the current program was on accuracy, timeliness, and usability of source data entry. However, it was evident that the savings/investment ratio could be improved if computers were used for more than just data entry. Also, it would be difficult to achieve user acceptance of a device that could only be used for data entry. A minimum system, therefore, would permit data entry, retrieval of selected data, and automation of routine management reports. An expanded view of the use of automation, and probably one closer to optimum cost effectiveness, would provide comprehensive automation for personnel functions so that data entry would take place in the course of routine office activities.

Effectiveness of the Approach Used in this Research

The approach used in this research was a combination of field and laboratory testing. The dominant feature, however, was the use of a test device in a working field office. It therefore allowed identification of "real" problems as they arose in a typical Navy office

environment. There is really no substitute for this approach, for Navy personnel cannot be made available for extensive laboratory testing, nor could an office environment be economically simulated in a laboratory.

The problems of user acceptance have already been described and represent a major difficulty with the combined field/laboratory testing approach. The field office is an inappropriate environment for testing marginal designs. If the test device doesn't offer sufficient advantage, it won't be used by office personnel. Consequently, research personnel must ensure that a candidate SODEM is refined in the laboratory to the point where its application in the field office will clearly represent an improvement over current office operation.

Guidelines for System Designers

The observations and findings of this research effort can be summarized in the following guidelines for the design of office data entry systems:

1. Minimize system response time--A hardware/software design goal should be to keep response time to less than 5 seconds.

2. Maintain adequate keyboard echo rates--The results of the Williges and Williges (1982) study indicate that echo rates should be less than 0.75 seconds.

3. Provide examples of inputs--Operators are less prone to make input errors when the system provides prompts with examples illustrating appropriate syntax.

4. Require manual review--User input should be reechoed in an appropriate format for review before it is incorporated into the data base.

5. Involve the end-users--Throughout the system life cycle, comments and suggestions should be solicited from personnel who are using the system.

RECOMMENDATIONS

1. Using the preliminary specifications provided in this report, develop an advanced SODEM for use at operational Source Data System (SDS) sites. This would provide a way to assess the validity and cost-effectiveness of the proposed design and will also provide a basis for enhancing the designs of current and future SDS research programs.

2. The query-response dialog should be studied to find ways of improving time performance. A query-response dialog was needed to provide for user control over system functions such as user log-in name, review, change, print, and the like. The dialog selected proved to be slow and errorprone; that is, it provided higher overhead time than the authors desired.

3. Field office operations should be studied further so that non-data-entry SODEM modules may be developed that will enhance the cost-effectiveness of the total source data system.

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APPENDIX A

SOURCE DATA ENTRY MODULE (SODEM) COMPONENT DESCRIPTION

SOURCE DATA ENTRY MODULE (SODEM) COMPONENT DESCRIPTION

This appendix describes the function and major characteristics of each component of the proposed SODEM (see Figure 5, page 21).

Interprocedure Buffer (IPB)

1. Function. The IPB will serve as a communication link between the procedures and a shared dynamic storage region. It will ultimately be under control of the supervisor module (SUP).

2. Uses. The IPB will be used as a buffer for keyboard input, display output, host system I/O, and disk I/O. Messages associated with events and sent from procedure to procedure will be contained in the IPB but pointers referring to the messages will be, in actuality, the entities passed back and forth. Information about the current state of the SODEM will be maintained in the IPB by SUP. In addition, a portion of the IPB will be used to store a complete record of the current transaction being processed by the operator so that reference may be made to previous occurrences in the transaction and the context of the transaction may be recovered if a host system failure should occur.

Supervisor Module (SUP)

1. Function. SUP will provide complete software control over the SODEM through the resource allocation process described on page 22. It will maintain information in the IPB concerning operations in progress so that other procedures may determine the context of operator and host system actions.

2. Procedure table. SUP will maintain a table listing each procedure and its current characteristics. Included in the table will be the procedure's name, its state (inactive, active, executing, suspended), its priority, the event(s) the procedure is waiting on, the entry point of the procedure, and a scratch area for any necessary pointers to related messages that the procedure may acquire when executing.

3. Events. In the SODEM context, the term "event" denotes I/O or module completion. Operationally, an event will be detected by an individual procedure, which will then place a code for that event in one of the CPU's general purpose registers and, if a message is to be associated with the event, a pointer to the message in another register. The procedure will then trap to SUP, which will then perform the arbitration process. Specifically, SUP will activate and deactivate procedures by making appropriate changes to the procedure table. The highest priority active procedure will be declared as executing, and the other active procedures will be suspended. When all bookkeeping is completed, SUP will branch to the executing procedure, which will retain control of the CPU until the next event occurs.

The I/O handlers will be connected to the interrupt vectors of the CPU and will provide all I/O processing for the SODEM. They will be invoked by requests from the procedures.

Terminal Handler (TH)

1. Function. TH will perform all terminal I/O operations, reading input from the keyboard, and displaying output on the CRT. Inputs from the keyboard will be placed in a buffer in the IPB and a pointer to the buffer will be passed to the requesting procedures.

In addition, TH will read the real-time clock and time-stamp the input character-by-character so that information regarding operator performance may be derived by subsequent procedures. Requests for display output will be accompanied by pointers to the text to be displayed that will, again, be located in a buffer in the IPB.

2. Interrupts. TH will respond to keyboard and display interrupts.

3. Events flagged. TH will detect and flag the initiation and completion of operator input and the completion of display output.

4. Potential refinements. Initial SODEM prototypes will include standard keyboard/CRT I/O as described above. After initial studies, it will be simple to modify TH to allow cursor positioning via key, joystick, or trackball control to provide simpler and more direct means of operator control of data entry. Similarly, the modular nature of the SODEM will allow the incorporation of a TH with touch panel and voice I/O capabilities.

Host Handler (HH)

1. Function. The function of HH will be analogous to that of TH, but HH will perform I/O from and to the host system.

2. Interrupts. HH will respond to interrupts resulting from reception of a transmission from the host and from the completion of transmission to the host.

3. Events flagged. HH will notify SUP upon the completion of host message transmission or reception.

Disk Handler (DH)

1. Function. All display information, including prompts, error messages, and HELP screens, will be stored on disk. Additionally, a number of SODEM data bases, such as operator performance information, translations tables, and procedural rules will be disk-based. DH will perform all I/O operations necessary to access this information.

2. Interrupts. DH will process disk read and write interrupts.

3. Events flagged. When a complete I/O operation, such as the recovery of an entire screen image from disk, has been performed, DH will flag a disk I/O event. SUP will then invoke the procedure that requested the operation. The remaining SODEM components are the procedures that perform the substantive SODEM functions. For each procedure, its function inputs, outputs, the events it detects and flags, and the events it waits for will be discussed. Other, procedure-specific characteristics will be presented in selected cases.

Operator Monitor Procedure (OMP)

1. Function. OMP will maintain an operator profile, a record of operator activities and performance, throughout a transaction and between transactions. This profile will be used by other procedures in adaptive error detection and correction, and in the selection of appropriate levels of prompt and message detail based on operator behavior. OMP will record response time, typing time, error rates, and characteristics of operator errors such as frequency based on error type and so on.

2. Inputs. Performance measurement and recording by OMP will be based on the time-stamped operator input provided by TH. In addition, display codes from which DH selects appropriate information to display will be provided by the host interface procedure (HIP) so that OMP is aware of the display that the operator is responding to.

3. Outputs. OMP will write information about the operator to the operator profile data base.

4. Invoking events. OMP will flag an event upon its completion.

Input Interpretation Procedure (IIP)

1. Function. Operator input may be in the form of data during a transaction or it may be a command to the host system or a request for a SODEM job performance aid. IIP scans operator input and invokes the appropriate procedure. The host interface procedure (HIP) is requested when data or a host command is input. Appropriate job performance aids or auxiliary function procedures are invoked when the operator's command calls for their services.

2. Inputs. IIP operates on operator input, provided by TH.

3. Outputs. Messages must occasionally be sent to the invoked procedures.

4. Invoking events. IIP is invoked upon the receipt of operator input.

5. Events flagged. Requests for the initiation of procedures will be the events flagged by IIP.

6. Data base accessed. A table relating commands to appropriate procedures will be used by IIP. If sufficiently compact, this table will be retained in memory; otherwise, it will be kept on disk and read via DH.

Host Interface Procedure (HIP)

1. Function. HIP will translate inputs from the host system to sequences of SODEM activities. In addition, HIP will translate operator inputs for transmissions to the host.

2. Outputs. HIP will send appropriately translated and formatted output to the host via HH.

3. Invoking events. HIP will be initiated upon the occurrence of events signaling receipt of prompts, menus, etc. from the host via HH. It will typically initiate the sequences of activities designed to provide the input necessary for the host and suspend itself until operator input is received.

4. Events flagged. In addition to flagging its own completion, HIP will request other operations, such as information display and the acquisition of operator input.

5. Data bases accessed. HIP will use two data bases. The first will be a translation table relating operator commands to appropriate host commands. The second will be a set of "programs" necessary to convert host prompts to sequences of SODEM activities. For instance, given a particular form that must be completed by the operator, the associated "program" would provide a sequence of prompts to display to the operator to acquire the necessary information.

6. Operator error prevention. Within HIP lie the first opportunities for the reduction of operator error in SODEM. The displays that HIP causes to be presented to the operator can greatly aid in eliminating input errors before they occur.

All data prompts will provide clear explanations of the data required. An example will be included for each type of datum to be entered. Where appropriate, a menu of acceptable responses will be given. In these cases, the operator will select the entry from the menu not by typing the entire entry or a numeric code, but instead by typing an allowable abbreviation, highlighted in the menu by capital letters, underlining, or reverse video.

Error Detection Procedure (EDP)

1. Function. EDP will detect and flag errors in the data entered by the operator.

2. Input. This procedure will process operator input provided through TH.

3. Output. When no errors are detected in the data, EDP will produce no output. When errors are detected, information concerning those errors will be provided to the error correction procedure (ECP).

4. Invoking event. The actions of EDP will begin when IIP has determined that the operator has entered data and an event requesting error detection has been flagged.

5. Events flagged. When EDP detects no errors in the entered data, it will merely flag its own completion event. When an error is detected, it will signal completion and request the error correction procedure (ECP).

4. Error detection methods. Errors will be detected by EDP in two major ways--by independent datum checks and by relational checks. All strictly numeric data will be subject to range checks. When a number is entered, it will be compared with the acceptable range and values outside the range will be flagged. Other data will be subject to table checks. Input will be tested to see that alphabetic characters are not substituted for numeric characters and vice versa. When input related to existing data is entered, certain identifying information will be compared with that existing data. For example, when a serviceman's record is to be updated, the social security number will be compared with the data base. If no match if found, an error will be flagged. Word entries, such as the names of persons and places, will be tested for spelling accuracy against an internal vocabulary.

Within a given transaction, such as the completion of a form to update personnel records, a number of relational data checks will be made. Dates will be compared against the current date. Disparities between date of birth, date of enlistment, date of marriage, and dates future actions are to be taken will be sought for. In each case, certain minimum thresholds (to be determined on case-specific bases) will be used. Spelling consistency tests will be made on word entries such as names and addresses. In the case of each relational check, a table of relational links within a transaction will be maintained by EDP to be used in the detection process.

In addition to these error detection methods, EDP will help reduce errors by a suitable redefinition of errors. In most data entry systems, rather rigid format is often required with respect to certain items such as dates, times, codes, and numeric values. By allowing more flexibility in such items, time required for operator correction of errors can be minimized. In a case where an operator enters the data in an incorrect yet

recognizable format, EDP will flag it as a potential error and request the error correction procedure to correct it with minimal or no operator intervention.

Error Correction Procedure (ECP)

1. Function. ECP will correct data entry errors both automatically and through operator assistance.

2. Inputs. The inputs to ECP will be operator input via TH and error information, as provided by EDP.

3. Outputs. ECP will present error messages and data prompts to the operator via TH. When the data in error has been corrected, it will be passed to the data reformatting procedure (DRP).

4. Invoking events. This procedure will be initially invoked upon a request for error correction by EDP. When corrections are being made with operator assistance, it will subsequently suspend itself and wait for operator input to resume.

5. Events flagged. When an error has been corrected, ECP will flag its completion and request the execution of the data reformatting procedure.

6. Error correction methods. The simplest form of error correction will involve operator assistance. ECP will request the display of an error message that explains the nature of the error and how it is to be corrected. The operator will be required to reenter only that data which is in error. In no case will the operator be requested to reenter correct data. In many cases, this will mean that the CRT cursor will be positioned at the incorrect portion of the entry and only a few characters will need to be typed. When information about operator experience with the SODEM is available from the operator profile data base, the level of detail of the error messages and data prompts will be keyed to that information. Relatively new users will be given extensive error diagnostics and instructions on corrections. Experienced users will be presented with concise messages intended to refresh their memories about data entry procedures.

In the cases of some errors, automatic correction by ECP will be possible. For example, when punctuation is omitted from an entry, it will be scanned for proper overall format and appropriate punctuation will be inserted. When a date is entered in numeric format instead of the use of an alphabetic abbreviation for month, the conversion will be made. If the operator profile data base permits, records will be kept of habitual errors of individual operators, along with the appropriate corrections. When sufficient data are gathered on these errors, the corrections will be made automatically. One important issue that remains unresolved by this research, however, is whether or not the operator should be called upon to validate corrections made automatically. Prototype testing will be required to answer this question.

Data Reformatting Procedure (DRP)

1. Function. DRP will convert data to a form acceptable to the host system. In many cases, no reformatting will be necessary. In others, abbreviations will be expanded, codes will be interpreted, and punctuation will be inserted or changed.

2. Input. TH will provide the operator input used by DRP.

3. Output. DRP will produce correctly formatted data for the host system.

4. Invoking event. DRP will be invoked by requests from EDP and ECP.

5. Events flagged. An event will be flagged by DRP upon its completion. Additionally, DRP will request HH to send the data to the host.

Job Performance Aid (JPA) Procedures

The SODEM will incorporate a number of JPAs, their specific natures depending on the particular SODEM application. The initial prototypes will include a subset of the following JPAs as procedures.

1. On-line HELP directives. The most basic JPA incorporated in the SODEM will be a HELP system that provides information about particular commands and data elements. HELP will be invoked by the operator by typing a question mark or the word "help" in response to a SODEM prompt. When this is scanned by IIP, the HELP procedure will be invoked to display screens of information explaining the matter in question to the operator. The HELP procedure will use the current state information in the IPB to determine what the operator is asking about. Later versions will use information from the operator profile data base to determine what level of detail is required by the operator. Like the error messages and prompts of ECP, the HELP messages for inexperienced users will be quite extensive while those for experts will be concise. Advanced versions of HELP will key the level of detail to the operator's experience with the particular type of command or transaction in progress rather than just a general level of experience. An extension of the HELP procedure will be one that provides on-line access to procedural directives, thereby eliminating the need for the operator to break from the transaction to refer to hard-copy documents. The operator will be allowed to branch within the system to any manual required to complete the transaction without losing any portion of the transaction.

2. On-line training. Operator performance assessment by OMP will provide a diagnostic tool to identify operator skill deficiencies. These may in turn be remedied by an on-line training procedure. This procedure will provide tutorial examples of system use and transaction processing and include embedded exercises and testing. Such features will minimize the need for intervention by supervisory personnel.

3. Scheduling. A scheduling procedure will maintain a table of appointments and deadlines for operators and remind them, in a timely manner, of these obligations. Entries will be added by the operators themselves or by supervisory personnel via the host system.

4. Computational aids. Computations are sometimes necessary to complete data entry tasks. A calculator procedure will be available to compute numeric quantities, elapsed time, and so on

5. Transaction suspension/resumption. Data entry transactions are often interrupted by higher priority tasks. With the use of the SODEM, when such an event occurs, the operator will invoke a transaction suspension/resumption procedure that will terminate the current transaction and copy the transaction record in the IPB to disk storage. It will then make an entry in the scheduling table to remind the operator of the suspended action. When the operator later requests the resumption of that transaction, the procedure will recover the record, re-initiate the transaction automatically, and bring the transaction up to its point of interruption. As this is being done, the information being sent to the host will also be displayed to the operator so the transaction can be completed with minimal difficulty.

6. Office automation. A number of standard office automation features will also be introduced into future versions of the SODEM. Among them, word processing and electronic mail should be useful to data entry personnel.

Auxiliary Function Procedure (AFP)

It will be possible to incorporate a number of additional features into the SODEM. Reference has been made to operator performance assessment, which will be of prime importance to supervisory personnel in data entry system management and planning. An auxiliary function procedure could be incorporated in the SODEM to provide operator performance reporting to authorized personnel.

APPENDIX B

SYSTEM TIMING PARAMETER STUDY

SYSTEM TIMING PARAMETER STUDY

The basic SODEM concept is one of a front-end module that can provide (1) information to the host computer system as needed and (2) a desirable user interface. There is a limit, however, to the extent to which a SODEM can provide user-interface characteristics independent of the host characteristics. Timing characteristics, for example, are important to the user, and there is a limit to the extent to which SODEM can cover up delays in transmission to, and processing by, the host computer system. Consequently, as an augmentation to the function description for SODEM, a study of system timing parameters was performed for NAVPERSRANDCEN (Williges & Williges, 1982). The following is a brief summary of some of the salient features of that study.

Method

The task was a simulation of a Navy personnel records-keeping task in which the operator used an interactive computer terminal. The particular transaction was completing a form similar to the Navy pay order form used to issue a temporary pay change. Alphanumeric information was entered into a series of 12 fields; these included items such as date, name, social security number, duty station, amount of pay, reason for change, etc. Specific Navy format rules were followed for entering the data. Each subject was required to perform either ADD or CHANGE transactions on these records.

Four undergraduate students were used as subjects. Four variables relating to various timing paramters of the computer system were manipulated; these included system delay (SD), display rate (DR), echo rate (ER), and buffer length (BL). These parameters controlled the delay time between an operator's input and the computer response, the rate at which characters were displayed on the display screen, the delay between a keystroke and the appearance of that character on the screen, and the number of characters that could be typed and held in a buffer awaiting display.

Three classes of measurements were taken: work sampling, embedded performance measurement, and operator satisfaction ratings. Work sampling measurement consisted of the analysis of what each subject was viewing and doing based on closed-circuit television data. Embedded performance measurement consisted of automatic analysis of typing rate, user response time, user ready time, number of ready responses, number of character erasures, and checking time. Satisfaction ratings were collected using a ten point Likert-type rating scale.

Results

System timing variables affect the amount of time devoted to various aspects of the task. The proportions of the total time devoted to various task components was as follows:

Task Component	Proportion
1. Viewing the keyboard while entering data.	28.3%
2. Looking at the display.	26.4%
3. Display/typing.	23.4%
4. Looking at information.	16.4%
5. Information/typing.	3.9%
6. Looking at keyboard.	1.7%

Polynomial regressions of the time spent in various aspects of the task show that the operator spent increasingly more time viewing the display as additional delays were introduced.

A polynomial regression plot of the operator's overall rating of satisfaction as a function of SD and ER showed that the subjects were clearly satisfied with the fastest SD and ER, but their satisfaction decreased rapidly as timing delays were introduced. The subjects expressed almost total dissatisfaction when SD was greater than 5 seconds and ER was more than 0.75 seconds delayed.

To estimate the underlying behavioral dimensions, a principal components analysis was conducted, leading to identification of three principal components: production, waiting, and planning. The component named production was most heavily weighted on typing rate and operator ratings of echo rate, buffer length, speed, accuracy, and overall satisfaction. The waiting dimension consists of metrics such as time spent viewing the display, field entry and next field ready times, operator ready responses, and operator ratings of system delay. The planning dimension included variables such as time spent by the operator viewing the display while typing, next field and field entry user response time, and operator rating of the cueing tones. A multivariate response surface for production was generated. It showed that production activity is highest at the shortest system delay and keyboard echo rate, and as delays are introduced, production decreases markedly. For further discussion concerning the principal components analysis and the three components identified, see Williges and Williges (1982).

It is clear from these data that system delay parameters have marked effect on operator performance, and that minimum delay is necessary for maximum data entry performance. It follows that the success of SODEM and SDS will depend on fast response from the host computer. Relatively small system delays will have serious consequences in terms of task performance and acceptance.

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